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Calspan SRL Corporation

[REDACTED] New York [REDACTED]

CALSPAN ON-SITE AIR BAG DEPLOYMENT INVESTIGATION

CALSPAN CASE NO. 95-09

VEHICLE #1 - 1992 FORD TAURUS GL STATION WAGON (AIR BAG EQUIPPED)

VEHICLE #2 - 1989 CHEVROLET S10 PICKUP TRUCK

LOCATION - STATE OF GEORGIA

CRASH DATE - [REDACTED] 1994

Contract No. DTNH22-94-D-07058

Prepared for:

**U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590**

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. 95-09	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Calspan On-site Air Bag Deployment Investigation Vehicle #1 - 1992 Ford Taurus GL Station Wagon Vehicle #2 - 1989 Chevrolet S10 Pickup Truck Location - State of Georgia		5. Report Date: [REDACTED] 1996	
		6. Performing Organization Code	
7. Author(s) Accident Research Group		8. Performing Organization Report No.	
9. Performing Organization Name and Address Transportation Sciences Center Accident Research Group Calspan SRL Corporation [REDACTED] [REDACTED] New York [REDACTED]		10. Work Unit No. 1115 (5260-5269)	
		11. Contract or Grant No. DTNH22-94-D-07058	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. Type of Report and Period Covered Technical Report Crash Date: [REDACTED] 1994	
		14. Sponsoring Agency Code	
15. Supplementary Notes On-site investigation of an air bag deployment crash in which the 35 week old fetus of the unrestrained driver in Vehicle #1 sustained fatal injuries as the result of contact with the driver side air bag module cover and air bag.			
16. Abstract <p>Vehicle #1 was traveling west on the right side of a two lane, undivided, local, dry dirt roadway and completed travel around a right curve (refer to photograph #1) when the driver, a 29 year old female who was 157.5 cm (62.0") tall, weighed 74.8 (165.0 lb.), and 35 weeks pregnant noticed the approach of Vehicle #2 traveling in the center of the roadway traveling in the opposite direction. The driver of Vehicle #1 applied the brakes to a locked wheel position and skidded a driver estimated distance of 4.5 m (15.0') prior to the point of impact (POI).</p> <p>The left front corner of Vehicle #2 struck the left corner of Vehicle #1 at a 12 o'clock principal direction of force (PDOF). Both vehicles rotated in a counterclockwise rotation and came to final rest positions (FRP) on the roadway. The driver of Vehicle #1 stated her travel speed was 53.1 km/h (33.0 mph) prior to the POI.</p> <p>During the crash phase, the driver side air bag system of Vehicle #1 deployed. The upper flap of the air bag module separated normally along the horizontal seam line and rotated upward. In so doing, it contacted her abdominal area resulting in vertically oriented burnish marks on the surface of the flap and a blue/black transverse transfer mark along the upper cosmetic seam line of the flap which was consistent with the color of the driver's shirt. The driver sustained contusions and abrasions of the left abdominal area. The abrasion was located just below the left ribs. The driver suffered an abruption of the placenta from the uterine wall resulting in internal hemorrhage.</p> <p>The driver was transported to a local trauma center where an ultrasound test revealed the absence of fetal heart tones. The expired fetus was delivered vaginally through induced labor on the same day of the crash. A radiological examination of the fetus did not reveal any fractures. The fetus weighed 30.1 g (6.6 lbs.) and measured 50.8 cm (20.0") in length. The driver was admitted to the hospital where she was discharged three days later.</p> <p>The driver of Vehicle #2 was transported to an area hospital where he was treated and released for a laceration of the mouth.</p>			
17. Key Words Supplemental Restraint System (SRS) Driver side air bag, air bag module cover Delta V 13 km/h (8 mph) AIS-3 (serious) level injury Two vehicle off-set frontal crash Unrestrained occupant in Vehicle #1		18. Distribution Statement General Public	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

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CALSPAN ON-SITE AIR BAG DEPLOYMENT INVESTIGATION

CALSPAN CASE NO. 95-09

VEHICLE #1 - 1992 FORD TAURUS GL STATION WAGON (AIR BAG EQUIPPED)

VEHICLE #2 - 1989 CHEVROLET S10 PICKUP TRUCK

LOCATION - [REDACTED]

This investigation was initiated in response to a notification received by the National Highway Traffic Safety Administration (NHTSA) through the Auto Safety Hotline that an air bag vehicle was involved in a head-on collision. It was reported that the air bag did not deploy and the seatbelt did not work which resulted in the death of an eight month old fetus. The notification was received at the Auto Safety Hotline five months after the crash. A Calspan Crash Reconstructionist was notified seven days later and was on-site two weeks after receiving notification. Scheduling problems with the driver's legal council delayed the on-site investigation.

The air bag equipped vehicle was stored in a parking lot behind the attorney's office and was found with locked doors. The vehicle was reportedly inspected by two experts hired by the law firm prior to this investigation. With the exception of personal belongings removed from the vehicle, the interior and exterior evidence appeared to be undisturbed. There were no on-scene photographs available to verify the condition of the vehicle immediately following the crash.

SUMMARY

This crash involved a head-on impact between a 1992 Ford Taurus GL station wagon (Vehicle #1) and a 1989 Chevrolet S10 pickup truck (Vehicle #2) which occurred in [REDACTED], 1994. Vehicle #1 was traveling west on a two lane, undivided, county, dry dirt, 3.5 percent slope roadway and was completing travel in a right curve (refer to photographs #1-#4 on pages A-1, A-2) when the driver, a 29 year old female who was 157.5 cm (62.0") tall, weighed 74.8 (165.0 lb.), and 35 weeks pregnant noticed the approach of Vehicle #2 traveling eastbound in the center of the roadway. She claimed the other driver's attention was directed away from her vehicle (i.e., looking off road toward the south) and determined Vehicle #2 would not move over to its side of the roadway.

The driver of Vehicle #1 applied the brakes to a locked wheel position and skidded a driver estimated distance of 4.5 m (15.0') prior to the point of impact (POI). The left front corner of Vehicle #2 struck the left corner of Vehicle #1 at a 12 o'clock principal direction of force (PDOF). Both vehicles came to final rest positions (FRP) on the roadway as shown in scaled scene schematic on page 4. The driver of Vehicle #1 stated her travel speed was 53.1 km/h (33.0 mph) prior to the POI.

It was determined from the inspection of the vehicle interior and injury data that the driver was not wearing the available three point manual lap and shoulder belt at the time of the crash. This conclusion was based upon the following data:

- The steering column was displaced forward which was attributed to loading by the driver during the crash. Column displacement was considered a primary indicator that the driver was not restrained by the restraint belt.
- In light of the steering column displacement, if the occupant had been wearing the restraint belt system in a loosely adjusted setting, then contact evidence on the belt system from the deploying air bag would have been expected. The restraint belt, however, did not exhibit any related contact physical evidence (e.g., abraded belt fabric, air bag fabric transfer, etc.).
- The driver did not experience any belt related injuries such as abrasions and/or contusions to her shoulder, chest, and pelvic area. The driver, however, experienced a bruise to the top of head which was attributed to her unrestrained torso being elevated by the expanding air bag and contacting the roof side rail.

The driver of Vehicle #1, however, was confident that she was wearing the restraint belt at the time of the crash. She described the belt as being worn in the normal position with the lap portion low on her lap and the torso belt across her left shoulder and chest. She was unsure if she had pulled the lap belt tight across her lap.

The driver moved forward in response to the pre-impact braking and impact forces and displaced the steering column in a forward direction prior to the air bag deployment sequence. Due to the low delta V (13 km/h (8 mph)), it was reasoned that the air bag deployment initiation sequence occurred late in the crash phase and contacted the driver as she was displacing the steering column.

The upper flap of the air bag module separated along the horizontal seam line and rotated upward. In so doing, it contacted her abdominal area as noted by vertically oriented burnish marks on the surface of the flap. Additionally, there was a blue/black transfer mark along the upper cosmetic seam line of the flap that was consistent in color with the driver's shirt.

The driver was wearing a dark blue 100 percent cotton pullover shirt with a black and silver trophy cup designer logo on the front side. The garment was ripped in an area over the left side of the chest which resulted from contact by the upper air bag module flap during the supplemental restraint system (SRS) deployment. A blue and gray fabric transfer mark measuring 12.7 cm (5.0") x 14.7 (5.8") was noted on the instrument panel side of the air bag in the 6 o'clock position which was consistent with the color of the driver's shirt.

The driver sustained contusions and abrasions of the left abdominal area. The driver suffered an abruption of the placenta from the uterine wall resulting in internal hemorrhage. The driver was later given two units of packed red blood cells in the emergency room at the trauma center.

The driver of Vehicle #1 exited the vehicle under her own power and summoned help from a local resident. Upon returning to her vehicle, she sat on the ground where she reportedly passed out. Rescue arrived and transported her to a local hospital where she was admitted for treatment.

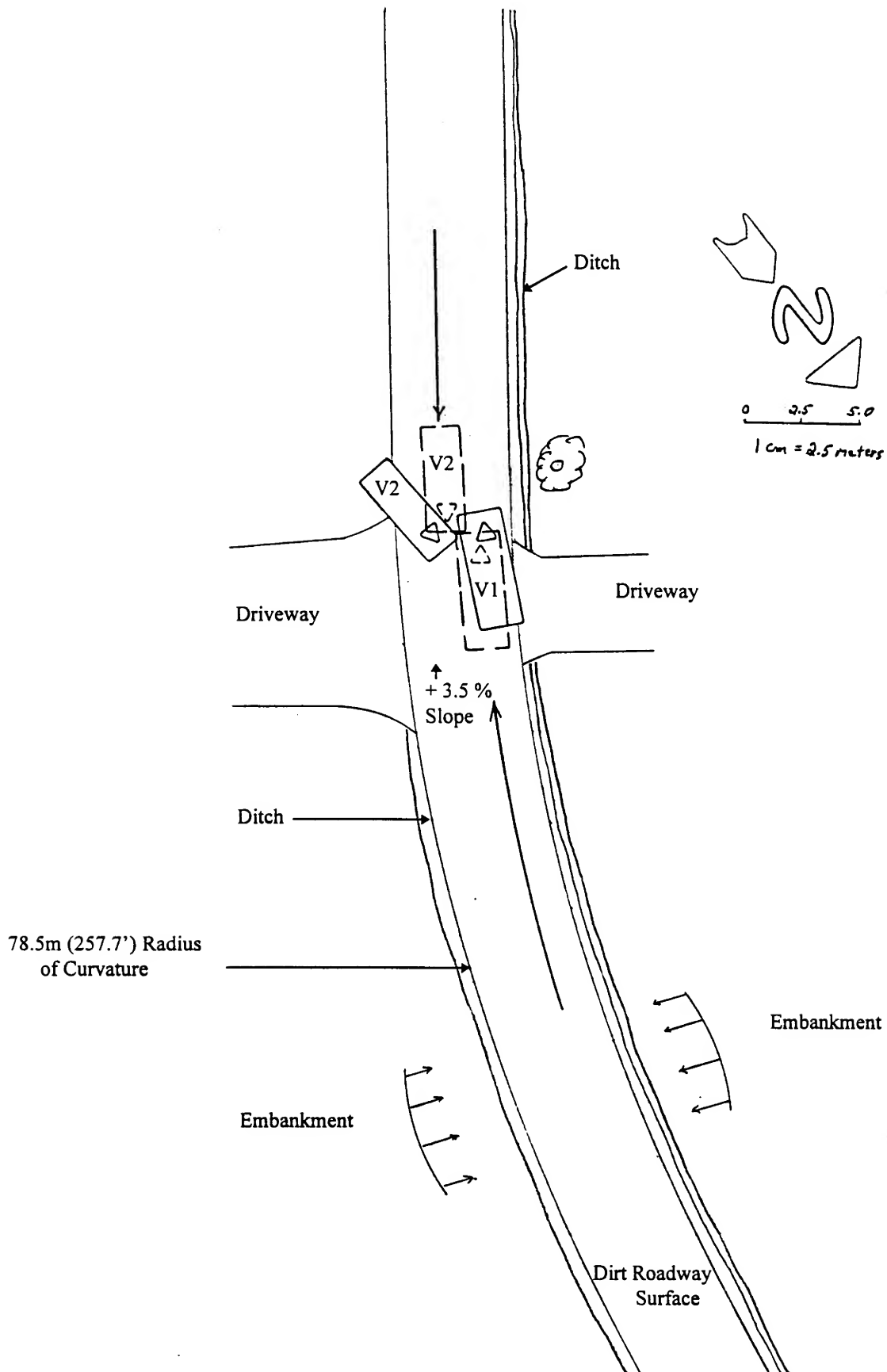
An ultrasound test was performed which found the absence of fetal heart tones. The thirty-five week old fetus which weighed 30.1 g (6.6 lbs.) and measured 50.8 cm (20.0") in length was delivered vaginally through induced labor on the same day of the crash. A radiological test was completed on the fetus with no fractures noted. An invasive autopsy was not performed.

The 70 year old male driver of Vehicle #2 was not restrained and struck his face on the steering wheel resulting in a laceration of the mouth. He was transported to a local hospital where he was treated and released.

The damage routine of the SMASH speed reconstruction program computed the delta V for Vehicle #1 as 13 km/h (8 mph) and 16 km/h (10 mph) for Vehicle #2. The trajectory algorithm calculated the impact speed of 18 km/h (11 mph) for Vehicle #1 and 24 km/h (15 mph) for Vehicle #2.

The [REDACTED] Police Department responded and arrived on-scene eighteen minutes after notification. EMS personnel arrived on scene within four minutes and transported the injured to an area hospital.

Scene Schematic
Calspan Case No. 95-9



CRASH DATA	
Location:	Two lane undivided county route
City/Township:	State of Georgia
Area/Type:	Rural/residential
Investigating Police Agency:	State police
Accident Type:	Two vehicle off-set head-on crash
Air Bag Vehicle Driver Injury Severity:	AIS-3 (Serious)
AMBIENCE	
Viewing Conditions:	Daylight
Weather:	Clear/Sunny
Road Surface:	Dry
HIGHWAY	
Type:	County route
Number Of Lanes:	2
Roadway Width:	4.8 m (15.7')
Surface:	Dirt
Median:	None
Edge:	North edge, 0.9 m (3.0') dirt South edge, ditch line
Vertical Alignment:	+3.5 percent slope westbound
Horizontal Alignment:	Curve
Estimated Coefficient Of Friction:	0.65
Traffic Density:	Light
TRAFFIC CONTROLS	
Signals:	None
Signs:	None
Roadway Markings:	None
Speed Limit:	89 km/h (55 mph)

VEHICLE #1 DESCRIPTION	
Description:	1992 Ford Taurus GL station wagon.
V.I.N.:	1FACP57U6NA [REDACTED].
Color:	Dark purple.
Odometer:	79,174 km (49,198 miles).
Engine:	3.0 L.
Transmission:	3 speed automatic.
Steering:	Power.
Brakes:	Power assisted front wheel disc and rear drum brakes.
Padding:	Soft edge steering wheel rim and air bag module cover, sunvisor, seats and seat arm rests, roof liner, door panels and arm rests, upper and mid instrument panel.
Active Restraints:	3-point lap and shoulder belts in all four out-board seating positions, lap belt in the second row center seat position.
Passive Restraints:	Driver side Supplemental Restraint System (SRS) which deployed upon impact with the front of Vehicle #2.
Defects:	None.
Tow Status:	Towed from the scene due to damage.

VEHICLE #2 DESCRIPTION	
Description:	1989 Chevrolet S10 pickup truck.
V.I.N.:	1GCCS14Z3K2 [REDACTED].
Color:	Blue.
Odometer:	299,339 km (186,006 miles).
Engine:	4.3 L.
Transmission:	Automatic.
Steering:	Power.
Brakes:	Front disc and rear drum brakes.

Padding:	Unknown, vehicle interior components were removed by salvage prior to vehicle inspection.
Active Restraints:	3-point lap and shoulder belts in the two outboard rear seat positions.
Passive Restraints:	None.
Defects:	Unknown.
Tow Status:	Towed from the scene due to damage.

VEHICLE DAMAGE

Vehicle #1

Exterior:

The frontal plane of the 1992 Ford Taurus GL station wagon struck the frontal plane of the 1989 Chevrolet S10 pickup truck. Direct contact was noted at the left front corner of the bumper surface, grille, and hood area. The front bumper sustained a maximum rearward displacement of 3.8 cm (1.5") and the left corner of the hood was displaced rearward a maximum of 38.1 cm (15.0"). The combined direct and induced damage length measured 139.7 cm (55.0") (refer to photographs #18, #19, #22 - #25 on pages A-9, through A-13). Measured crush values are listed below:

Bumper Crush		
C ₁ = 3.0 cm (1.2")	C ₂ = 2.0 cm (0.8")	C ₃ = 7.0 cm (2.8")
C ₄ = 10.0 cm (3.9")	C ₅ = 3.0 cm (1.2")	C ₆ = 2.0 cm (0.8")

Components damaged in the crash included: the front bumper fascia, the grille; the left headlight and directional light assembly; the hood; the left front fender; the radiator; and the windshield. The left front bumper energy absorption device (EAD) was displaced rearward the full stroke value of 5.1 cm (2.0") with full restitution while the right EAD was not displaced (refer to photographs #29, #30 on page A-15).

CDC: 12-FLEE-3

Repair Cost: \$4,761.48

Vehicle #1

Interior:

Damage to the interior was associated with driver contacts. The driver side air bag module cover exhibited several burnish marks and fabric coloration transfers (refer to photographs #44 - #46 on pages A-22, A-23). A dark blue/black transfer was observed along the entire upper cosmetic relief line which was located 3.0 cm (1.2") below the top of the upper flap. This transfer was consistent in color with the color of the driver's shirt (refer to photographs #57, #58 on page A-29).

A large burnish mark measuring 8.9 cm (3.5") vertically from the horizontal tear seam line and extending 3.1 cm (1.25") laterally was located 3.1 cm (1.25") right of the left vertical tear seam. A small burnish mark measuring 1.9 cm (0.75") long and 9.5 mm (0.4") wide was oriented in an angular direction with the upper point located 5.7 cm (2.25") from the right vertical tear seam line and the lower point located 3.8 cm (1.5") from the right tear seam line. There was a light burnish mark around the "Ford" insignia located in the bottom right corner of the upper module flap.

The lower air bag module flap exhibited a dark color burnish mark along the horizontal seam line (refer to photographs #47, #48 on page A-24). The mark measured 12.7 cm (5.0") laterally and 7.9 mm (0.3") vertically and began at the left vertical tear seam line. Refer to the diagram on page 12 for a detailed schematic of the contact evidence on the driver side air bag module cover.

The driver air bag exhibited transfers which were consistent in color with the color of the driver's shirt (refer to photographs #49, #50 on page A-25). A 2.5 cm (1.0") long light blue transfer was noted on the front surface of the air bag located 12.7 cm (5.0") left of the center "target" area. A large blue/gray fabric transfer measuring 14.6 cm x 12.7 cm (5.75" x 5.0") was noted on the back surface of the air bag in the six o'clock sector. It was located along the perimeter of the air bag and had an appearance of a heavier transfer coloration along the left side of the transfer (refer to air bag diagrams on pages 13-14 for detailed documentation). This transfer resulted from contact with the driver's abdominal area.

The windshield exhibited a spider web contact pattern which was consistent with an occupant hand contact. It was located 21.6 cm (8.5") left of the vehicle centerline and 11.1 mm (0.4") below the windshield header. Although the driver did not report any correlating lesion, this damage was probably caused by contact of the driver's right hand during the crash.

The knee bolster exhibited a light color transfer on the left side of the steering column which was located 45.7 cm (18.0") left of the vehicle centerline. This evidence was associated with contact by the driver's left knee (refer to photograph #38 on page A-19).

A light color transfer mark was noted on the mid instrument panel 55.2 cm (21.75") left of the vehicle centerline (refer to photograph #37 on page A-19). This was associated with a contact by the driver's left hand.

The left side roof rail exhibited a dark color transfer mark which measured 28.2 cm (11.1") in length and was located 58.4 cm (23.0") rearward from the windshield header at the rearmost aspect (refer to photographs #64, #65 on paged A-32, A-33). This contact resulted from contact by the driver's head.

The driver seat (a six-way power seat) was adjusted 8.3 cm (3.25") rearward of the full forward position on a seat track which had an adjustment range of 22.9 cm (9.0"). The seat cushion appeared to be in the highest vertical setting measured at 31.8 cm (12.5") above the floor pan (the battery was discharged at the time of the inspection). The driver indicated the seat was in the same position at the time of the inspection as it was at the time of the crash. Photographs on pages A-26 thru A-28 show the driver seated in the driver seat and illustrates the relative distances of the driver's arms, upper torso and legs to the steering wheel and the foot controls. The seat back support measured 49.5 cm (19.5") rearward of the steering wheel hub at a height of 40.6 cm above the seat cushion. The seat back support angle measured 17 degrees rearward from vertical.

The tilt steering wheel was in the mid adjustment position at an angle of 29 degrees above horizontal. The steering column shear plate was displaced forward as the result of loading by the driver. The displacement measured 4.8 cm (1.875") at the left shear capsule and 3.8 cm (1.5") at the right shear capsule (refer to photographs #39, #40 on page A-20). The steering wheel was not deformed.

Other interior damage not related to the crash was noted to the left rear seat cushion. The driver indicated the abrasions on the seat fabric were related to the child safety seat used by her three year old son (refer to photograph #68 page A-34).

Vehicle #2

Exterior:

The frontal plane of the 1989 Chevrolet S10 pickup truck struck the frontal plane of Vehicle #1. The length of direct contact on the front bumper measured 38.1 cm (15.0"). The maximum crush of 31.75 cm (12.5") was located at the left front bumper corner. The crush pattern was typical of an off-set frontal impact configuration with deformation concentrated along the left frontal section of the vehicle (refer to photographs #69, #72 - #74 on pages A-35, A-36, A-37). The length of the direct and induced damage measured 143.5 cm (56.5") with crush values as listed below:

Front Bumper		
$C_1 = 31.75 \text{ cm (12.5")}$	$C_2 = 4.4 \text{ cm (1.75")}$	$C_3 = 0.6 \text{ cm (0.25")}$
$C_4 = 0 \text{ cm}$	$C_5 = 0 \text{ cm}$	$C_6 = 0 \text{ cm}$

Components damaged in the crash included the front bumper, the left headlight and directional light assembly, the hood, grille, radiator, left front fender, and the windshield.

CDC: 12-FLEE-2

Repair Cost: Not available, the insurance company sold the vehicle for salvage.

Vehicle #2:

Interior

Interior components of Vehicle #2 were removed by the salvage company prior to this investigation (refer to photographs #81, #82 on page A-41). The components removed included the front seat, front doors, steering column, and parts of the instrument panel.

The windshield had two focal spider web pattern fractures which were typical of contact points. One was located 32.4 cm (12.75") left of the vehicle centerline and 12.7 cm (5.0") below the windshield header and the other fracture was located nearby at 29.8 cm (11.75") left of the centerline and 19.1 cm (7.5") below the windshield header. These were attributed to contact by the driver's right hand. There was a hole in the windshield glazing located at the lower left corner adjacent to the upper A-pillar and instrument panel. This resulted from contact by the left rear corner of the hood as it was displaced rearward during the crash.

AIR BAG SYSTEM

Vehicle #1

The 1992 Ford Taurus GL station wagon was equipped with a driver side System 2 air bag Supplemental Restraint System (SRS) that deployed as designed during the crash. The System 2 was introduced in the Taurus and other Ford models beginning with the 1992 vehicle model year and utilized two primary crash sensors and one safing sensor (one less primary crash sensor than the System 1 design). The design of the System 2 primary crash sensors eliminated internal resistors which were present in the System 1 sensors.

The forward most primary crash sensor in Vehicle #1 was located on the upper radiator support bracket 4.1 cm (1.6") right of the vehicle centerline. The sensor measured 5.7 cm (2.25") in length and 4.4 cm (1.75") in width and was hidden from normal view by the "Vehicle Emission Control Information" placard plate shown in photographs #27, #28 on page A-14. This sensor was not damaged in the crash.

The driver/owner purchased the vehicle new in [REDACTED] of 1992 after placing an order with the new car dealership. She was aware of the air bag system which was part of the reason for the purchase. The owner indicated no SRS repairs had been performed on the vehicle since the purchase. The driver said the SRS readiness indicator light normally cycled on during vehicle start-up and subsequently cycled off.

Driver Side Air Bag

The driver side air bag module cover opened in the typical asymmetrical "H" pattern during the deployment sequence along the designated tear seam lines. The vertical length of the upper module flap measured 12.7 cm (5.0") and the lower flap measured 3.2 cm (1.25"). The lateral width of the flaps measured 20.6 cm (8.1") along the common horizontal tear seam line. The flap thickness measured 3.2 mm (0.125").

The air bag module flaps exhibited several burnish marks and fabric coloration transfer marks (refer to photographs #44 - #46 on pages A-22, A-23) from contact with the driver during the deployment sequence. A dark blue/black transfer was observed along the entire upper cosmetic relief line located 3.0 cm (1.2") below the top of the upper flap which was consistent in color with the color of the driver's shirt (refer to photographs #57, #58 on page A-29). A significant burnish mark which measured 8.9 cm (3.5") vertically and 3.1 cm (1.25") laterally was located 3.1 cm (1.25") right of the left vertical tear seam and began at the horizontal tear seam line.

A small burnish mark measuring 1.9 cm (0.75") long and 9.5 mm (0.4") wide was oriented in an angular direction on the upper module flap with the upper point located 5.7 cm (2.25") left from the right vertical tear seam line and the lower point located 3.8 cm (1.5") left from the right tear seam line. There was a light burnish mark around the "Ford" insignia located in the bottom right corner of the upper module flap.

The lower air bag module flap exhibited a dark color burnish mark along the horizontal seam line (refer to photographs #47, #48 on page A-24). The mark measured 12.7 cm (5.0") laterally and 7.9 mm (0.3") vertically and began at the left vertical tear seam line. Refer to the diagram on the page 12 for a detailed schematic of the contact evidence on the driver side air bag module cover. The right side of the flap was displaced forward beyond the steering wheel rim as the result of the air bag deployment sequence and the loading by the unrestrained driver on the air bag (refer to photographs #47, #48 on page A-24).

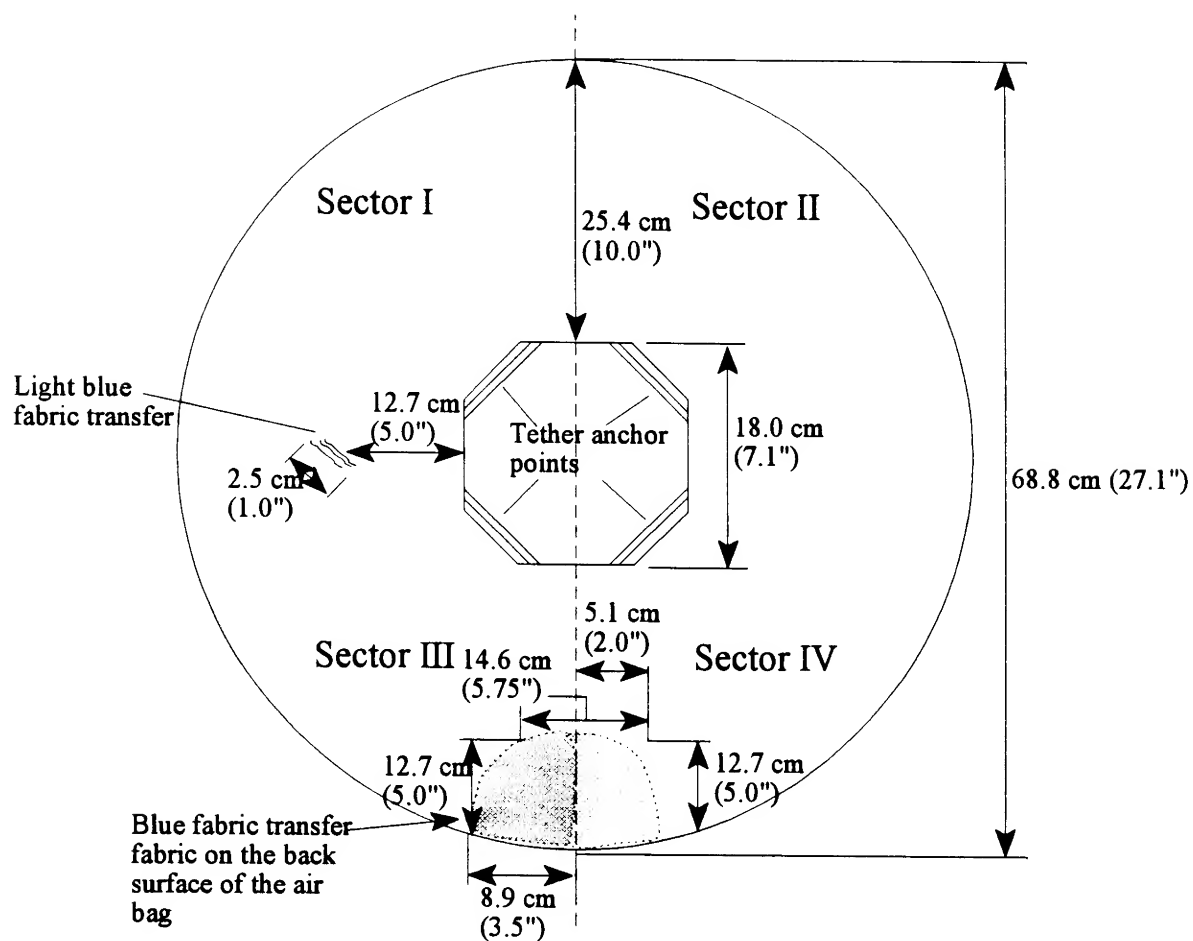
The air bag was designed with four tethers which were attached to the front side of the air bag forming an octagonal pattern center stitched area which measured 18.0 cm (7.1") vertically. There were two 2.5 cm (1.0") diameter vent ports located on the instrument panel side of the air bag in the twelve o'clock position and located 17.8 cm (7.0") apart. The air bag measured 68.8 cm (27.1") in diameter and the circumferential edge was stitched with a finished seam.

The driver air bag exhibited fabric transfers consistent in color with the color of the driver's shirt (refer to photographs #49, #50 on page A-25). A 2.5 cm (1.0") long light blue transfer was noted on the front surface of the air bag located 12.7 cm (5.0") left of the center target area. A large blue/gray fabric transfer measuring 14.6 cm x 12.7 cm (5.75" x 5.0") was noted on the back surface of the air bag in the six o'clock sector. It was located along the perimeter of the air bag and had an appearance of a heavier transfer coloration along the left side of the transfer pattern (refer to air bag diagrams on pages 13-14 for detailed documentation). This transfer resulted from

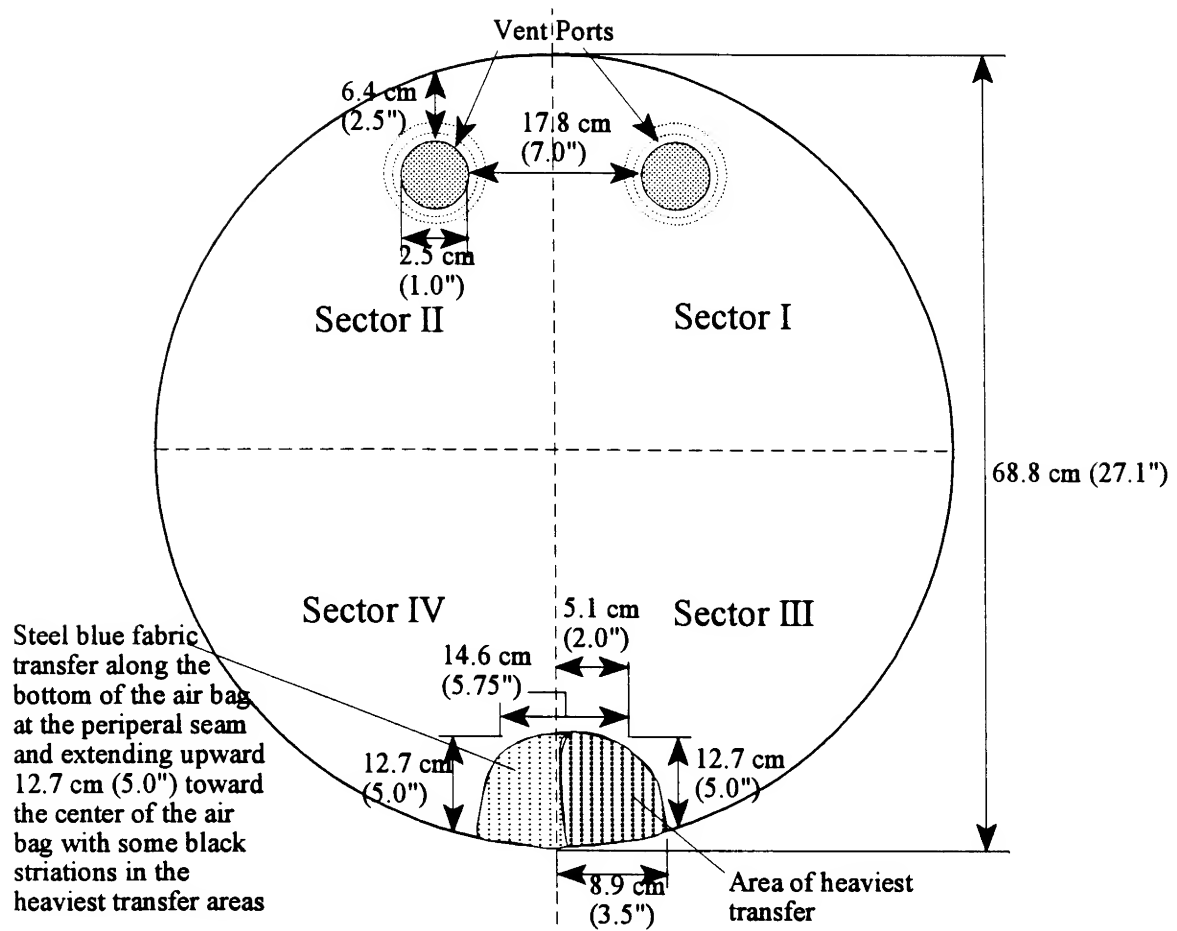
Driver Side Air Bag Module Cover



Front Surface of The Driver Side Air Bag



Back Surface of the Driver Side Air Bag



VEHICLE VELOCITY ESTIMATES

Crash Impact Sequence #1	Vehicle #1	Vehicle #2
Travel Speed:	53 km/h (33 mph) per driver	Unknown
Impact Speed:	18 km/h (11 mph)	24 km/h (15)
Total Delta V:	13 km/h (8 mph)	16 km/h (10 mph)
Longitudinal Delta V:	-13 km/h (-8 mph)	-16 km/h (-10 mph)
Lateral Delta V:	0 km/h	0 km/h
Energy Absorption:	9,648 joules (7115 ft-lb.)	23,247 joules (17,144 ft-lb.)

The impact speed and velocity changes were computed using the damage and trajectory algorithms of the SMASH program. The impact speeds reflect approximate speed ranges and should not be considered definite statements on actual impact speeds. Impact and final rest positions were derived using the description provided by the driver of Vehicle #1 and the police accident report. The roadway surface was a dirt composition which appeared to be routinely groomed by a road grader. Therefore, any physical evidence related to the crash (i.e., tire marks, fluid spills, debris) was not apparent at the time of the scene inspection.

COLLISION SEQUENCE

Pre-Crash:

In the hour preceding the crash, Driver #1's activities included the transportation of her three old son to a child day care center located approximately fifteen minutes from her residence. While returning home, Driver #1 stopped at a friend's house to purchase clothes for her son. The meeting, however, did not proceed as planned as her friend had overslept. Upon waking her and chatting for approximately fifteen minutes, Driver #1 departed for home without obtaining the clothes. Although the driver was confident she had put her restraint belt on before departing for home, evidence in the vehicle indicated she was unrestrained by the restraint belt at the time of the crash as described below:

- The steering column was displaced forward which was attributed to loading by the driver during the crash. Column displacement was considered a primary indicator that the driver was not restrained by the restraint belt.
- In light of the steering column displacement, if the occupant had been wearing the restraint belt system in a loosely adjusted setting, then contact evidence on the belt system from the deploying air bag would have been expected. The restraint belt,

however, did not exhibit any related contact physical evidence (e.g., abraded belt fabric, air bag fabric transfer, etc.).

- The driver did not experience any belt related injuries such as abrasions and/or contusions to her shoulder, chest, and pelvic area. The driver, however, experienced a bruise to the top of head which was attributed to her unrestrained torso being elevated by the expanding air bag and contacting the roof side rail.

Vehicle #1 was traveling south and negotiated a right curve with a 78.5 m (257.7') radius of curvature which changed the compass direction to a due west heading. The curve had a vertical slope of 4.4 percent 30 m (100') prior to the crash site which decreased to a 3.5 percent slope at the point of impact (POI). The curve was bounded by 0.9 m (3.0') wide ditches and dirt embankments which limited sight view of on-coming traffic (refer to photographs #1 - #4 on pages A-1, A-2). The driver indicated she was traveling at a speed of 53 km/h (33 mph) through the curve.

The driver was very familiar with this rural roadway as the crash site was located approximately five minutes from her home. She described this section of the roadway as a 'bad curve' due to the high speed traffic through the curve.

As the driver negotiated the curve, she noticed the approach of Vehicle #2 which she estimated at distance of fifty yards away. She described the other driver's attention as distracted and looking to his right. The position of his vehicle appeared to be encroaching in her lane.

The driver of Vehicle #1 claimed to have applied the brakes to a locked wheel position and steered to the right. The vehicle skidded for a driver estimated distance of 4.5 m (15.0') prior to the point of impact (POI). The unrestrained driver of Vehicle #1 moved forward in response to vehicle braking and was in contacted the driver air bag module cover at the time of the crash.

Crash:

The left front corner of Vehicle #1 contacted the left front corner of Vehicle #2 at a SMASH computed impact speed of 18 km/h (11 mph) for Vehicle #1 and 24 km/h (15 mph) for Vehicle #2. This resulted in a SMASH computed delta V of 13 km/h (8 mph) for Vehicle #1 which was sufficient to actuate the SRS.

The driver continued to move forward due to the crash force and compressed the steering column energy absorption device. This was noted by the movement of the steering column shear plate which measured 4.8 cm (1.875") of displacement at the left shear capsule and 3.8 cm (1.5") at the right shear capsule. As the air bag system initiated the deployment sequence, the module cover flaps pushed against the driver's abdominal area in response to the expanding air bag. The air bag then contacted her abdominal region.

Her right arm moved upward and contacted the windshield adjacent to the windshield header. This resulted in a crack in the glazing which was consistent with a hand contact pattern. Her

upper torso was then elevated upward and propelled rearward by the expanding air bag. A dark transfer mark was noted on the fabric along the left roof side rail which was attributed to contact by the driver's head as she was propelled rearward. The driver complained of bruising along the top of her head.

Post Crash:

Final Rest - Both vehicles came to final rest on the roadway in a counterclockwise rotational direction from their respective pre-crash travel directions. Vehicle #1 traveled an estimated 0.4 m (1.3') from POI to the FRP while Vehicle #2 traveled an estimated distance of 1.2 m (3.9').

Driver Activities - The driver of Vehicle #1 exited the her vehicle unassisted through the driver's door. She recounted the fact she was impeded from exiting the vehicle by the driver side air bag which she claimed deployed immediately following the crash. She was insistent that she had to "punch" the air bag out of her way. This reportedly made her angry because she could not exit the vehicle as quickly as she would have preferred. Contact evidence on the air bag module cover and air bag, however, indicated the air bag system deployed during the crash sequence.

The driver of Vehicle #1 looked over at the driver of Vehicle #2 who was also exiting his vehicle. She noticed that he was bleeding around the mouth. She yelled at him and said he was not looking where he was driving. He apparently agreed with her accusation.

The driver of Vehicle #1 then walked up a short driveway and yelled to a resident in the nearby house to summon help. She was returning to the vehicle when she became light headed and sat on the ground. She claimed to have lost consciousness and only awoke upon arrival of rescue personnel. The driver was transported to a local trauma center where she was admitted.

The driver said she felt the 35 week old fetus "kick" her shortly after exiting the vehicle, but did not detect any fetal activity during rescue procedures. Upon arrival at the hospital, an ultrasound test was performed with negative fetal responses. Labor was subsequently induced and the expired fetus was delivered during the evening hours of the same day.

Police Activities - The State Police responded to the crash. They arrived on-scene eighteen minutes after notification.

Rescue Activities - The EMS were notified at the same time as the State Police and arrived on-scene four minutes later. The driver of Vehicle #1 was transported via ambulance to a local medical facility and arrived one hour and fifty two minutes after EMS notification. The driver was aware that the travel route to the hospital was not the most direct and questioned the ambulance attendant. She was told the route was selected due to roadway problems along the preferred route. She claimed the roadway was uneven (dirt surface) which caused her pain particularly to her right side as the ambulance proceeded at a slow speed. She said the ambulance had to stop several times due to the discomfort she was experiencing.

Scene Clearance - Vehicle #1 and Vehicle #2 were towed from the scene due to damage. Vehicle #1 taken to a local storage yard and later stored behind the office of the representing attorney's office.

Human Factors/Occupant Data

Vehicle #1	Driver	Fetus
Age/Sex:	29 year old pregnant female.	35 week gestation/female.
Height:	157.5 cm (62.0").	52.1 cm (20.5").
Weight:	74.8 kg (165.0 lb.).	3.0 kg (6 lb. 10 oz.).
Manual Restraint System Usage:	Not wearing the 3-point lap and shoulder belt system based upon occupant contact evidence documented on vehicle interior components. The police accident report listed the driver as using the lap and shoulder belt.	
Usage Source:	Vehicle inspection.	
Eyewear:	Unknown.	
Jewelry:	Wedding ring on the left fourth finger, a sapphire ring on the left third finger, a ring on the right fourth finger, a watch on the left wrist.	
Clothing	A pull over dark colored (blue/black with a silver pattern) short sleeve cotton shirt, a red color shirt underneath, and long black maternity shorts (i.e., front expansion panel), refer to photographs #57 - #60 on pages A-29, A-30.	
Vehicle Familiarity:	Very familiar with vehicle, vehicle was primarily driven by the driver for work and errands, original owner.	
Route Familiarity:	Very familiar, resident of area for five years, traveled this route on a daily basis.	
Trip Plan:	Returning to residence after dropping off son at the nearby child day care center and a short visit with a friend.	
Type of Medical Treatment:	Transported to a local hospital where she was admitted for internal hemorrhaging and delivery of the expired fetus. The driver was discharged three days later.	

Vehicle #2	Driver
Age/Sex:	70 year male.
Height:	Unknown.
Weight:	Unknown.
Restraint System Usage:	Not wearing the 3-point manual lap and shoulder belt system.
Usage Source:	Vehicle inspection.
Eyewear:	Unknown.
Jewelry:	Unknown.
Cargo:	Unknown.
Clothing	Unknown.
Vehicle Familiarity:	Unknown.
Route Familiarity:	Very familiar, resident of area.
Trip Plan:	Unknown.
Type of Medical Treatment:	Transported to a local hospital where he was treated and released for a laceration of the mouth.

INJURY DATA

VEHICLE #1

DRIVER INJURY - 29 year old female		
INJURIES	SEVERITY (AIS-90)	SOURCE
1. Placenta abruption	543400.38	Driver side air bag module cover and air bag
2. Multiple abrasions of the abdominal wall	590202.12	Driver side air bag module cover and air bag

3. Multiple contusions of the abdominal wall with weeping in LUQ	590402.12	Driver side air bag module cover and air bag
4. Abrasion of the left elbow	790202.12	Driver's interior door surface
5. Abrasion of the left forearm	790202.12	Driver side air bag
6. Contusion of the left hand	790402.12	Left instrument panel
7. Bruising to top of head	190402.15	Left roof side rail
8. Contusion of the left ankle	890402.12	Brake pedal

Fetus - 35 week gestation period

Fetus was in a vertex position with skull and spine lying to the right side of the mother's pelvis. Radiography ruled-out any fractures although the driver was reportedly informed by a physician in the hospital that the fetus sustained a fracture of the skull. The death certificate listed the cause of death as the abruption of the placenta.

VEHICLE #2

DRIVER - 70 year old male		
1. Laceration of the lip	290600.18	Windshield

OCCUPANT KINEMATICS

Driver of Vehicle #1

At the time of the crash, the driver's seat was adjusted 8.3 cm (3.25") rear of full forward on a seat track with a measured seat adjustment range of 22.9 cm (9.0"). The driver was not wearing the available three-point manual lap and shoulder belt as described in the following discussion:

- The steering column was displaced forward which was attributed to loading by the driver during the crash. Column displacement was considered a primary indicator that the driver was not restrained by the restraint belt.
- In light of the steering column displacement, if the occupant had been wearing the restraint belt system in a loosely adjusted setting, then contact evidence on the belt system from the deploying air bag would have been expected. The restraint belt, however, did not exhibit any related contact physical evidence (e.g., abraded belt fabric, air bag fabric transfer, etc.).

- The driver did not experience any belt related injuries such as abrasions and/or contusions to her shoulder, chest, and pelvic area. The driver, however, experienced a bruise to the top of head which was attributed to her unrestrained torso being elevated by the expanding air bag and contacting the roof side rail.

Her hands were reportedly located at the 3 o'clock and 9 o'clock positions on the steering wheel. Just prior to the crash, the driver saw the approach of Vehicle #2 and applied the brakes in a panic braking maneuver.

In response to this braking, the driver moved forward and came in contact with the driver's side air bag module cover. She continued to move forward due to the crash force and compressed the steering column energy absorption device. This was noted by the movement of the steering column shear plate which measured 4.8 cm (1.875") of displacement at the left shear capsule and 3.8 cm (1.5") at the right shear capsule.

As the air bag system initiated the deployment sequence, the air bag module cover opened along the normal tear seam lines and contacted the driver's abdominal area. This was evident from the burnish marks along the surface of the upper flap of the module cover and the blue/black transfer mark along the lateral seam line of the lower flap.

This contact was associated with the 17.1 cm (6.75") long angular rip noted on the driver's shirt located 30.5 cm (12.0") above the bottom and 20.3 cm (8.0") left of the centerline of the shirt. It extended downward to a point 13.3 cm (5.25") above the bottom and 6.4 cm (2.5") left of the centerline (refer to photographs #56 - #58 on pages A-28, A-29).

The expanding air bag then contacted the driver's abdominal and lower chest area. This was evident by the very heavy blue/black fabric transfer located at the six o'clock sector along the perimeter on the back side of the air bag.

The driver's right hand was propelled upward by the air bag and struck the windshield adjacent to the windshield header as noted by the typical spider web contact pattern. The driver complained of a swollen right hand which was attributed to this contact mechanism.

The driver's left anterior forearm sustained an abrasion which was attributed to contact with the deploying air bag. Her left hand moved forward and contacted the left instrument panel resulting in a contusion of the left hand. Her left arm then moved laterally to the left where she contacted the driver's door surface resulting in an abrasion of the left elbow.

The driver contacted the knee bolster with her left knee. This was evident by the 5.1 cm x 5.1 cm (2.0" x 2.0") transfer mark located 45.7 cm (18.0") left of the vehicle centerline. Her left foot contacted the brake pedal resulting in a contusion of the left ankle.

Her torso was then propelled rearward and upward by the expanding air bag. A dark scuff mark was noted along the left side roof rail which was attributed to contact by the driver's head. She claimed to have sustained bruising to the top of her head.

The driver of Vehicle #1 came to rest in the driver's seat. She immediately attempted to exit the vehicle when she claimed to have been impeded by the deflating air bag. She did not remember hearing any noise from the air bag, but noticed a heavy concentration of smoke coming from the instrument panel.

Driver of Vehicle #2

The driver of Vehicle #2 was reportedly distracted prior to the crash and was looking to his right, away from the approach of Vehicle #1. He was not wearing a restraint belt. Upon impact, he moved forward in response and contacted the steering wheel rim with his face. This resulted in a laceration of the lip. The windshield had exhibited a typical spider web crack pattern which may have resulted from contact by the driver's right hand. The driver exited his vehicle without assistance.

Selected Prints
Calspan Case No. 95-09
State of Georgia



1. View of Vehicle #1's trajectory 107 m (350') prior to the POI.



2. View of Vehicle #1's trajectory 76 m (250') prior to the POI.



3. View of Vehicle #1's trajectory 46 m (150') prior to the POI.



4. View of Vehicle #1's trajectory 30 m (100') prior to the POI.



5. View of Vehicle #1's trajectory 15 m (50') prior to the POI.



6. View of Vehicle #1's trajectory at the POI.



7. Lookback view of Vehicle #1's trajectory from the FRP.



8. Lookback view of Vehicle #1's trajectory 30 m (100') from the POI.



9. Lookback view of Vehicle #1's trajectory 91 m (300') from the POI.



10. View of Vehicle #2's trajectory 107 m (350') prior to the POI.



11. Trajectory of Vehicle #2, 76 m (250') prior to the POI.



12. Trajectory of Vehicle #2, 46 m (150') prior to the POI.



13. Trajectory of Vehicle #2, 30 m (100') prior to the POI.



14. Trajectory of Vehicle #2, 15 m (50') prior to the POI.



15. Trajectory of Vehicle #2, in the area of the POI.



16. Lookback view of Vehicle #2's trajectory from the FRP.



17. Lookback view of Vehicle #2's trajectory 15 m (50') from the POI.



18. Frontal view of the 1992 Ford Taurus GL station wagon (Vehicle #1) showing the overall plane of contact.



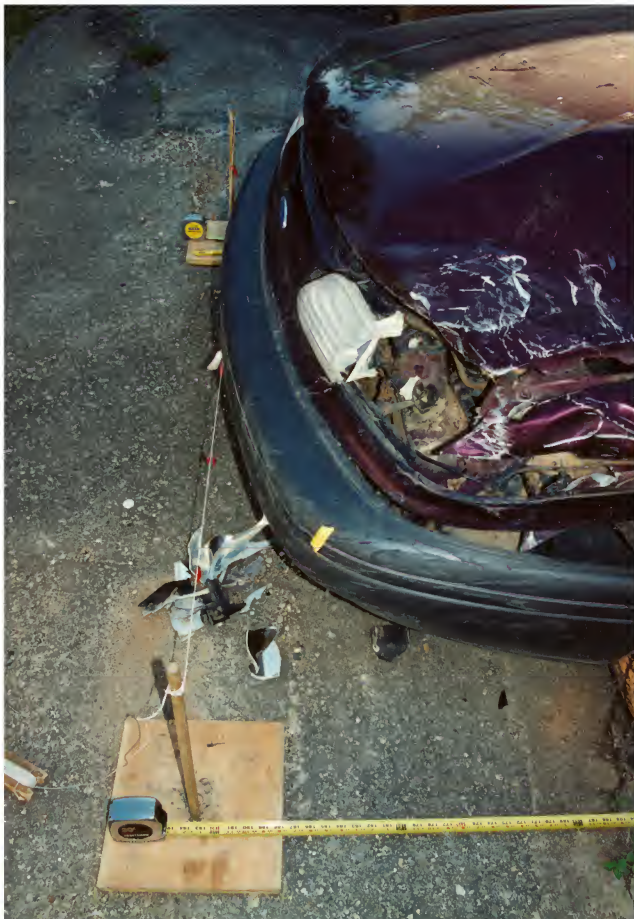
19. Closer view of the contact damage along the left front bumper, grille, and hood.



20. View of interior contact evidence on the windshield near the windshield header.

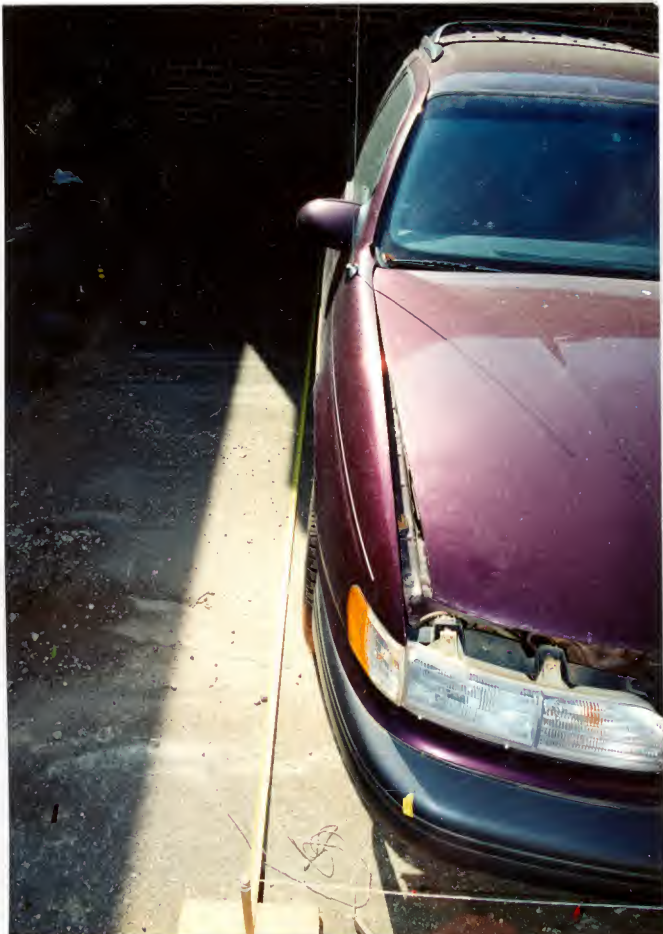
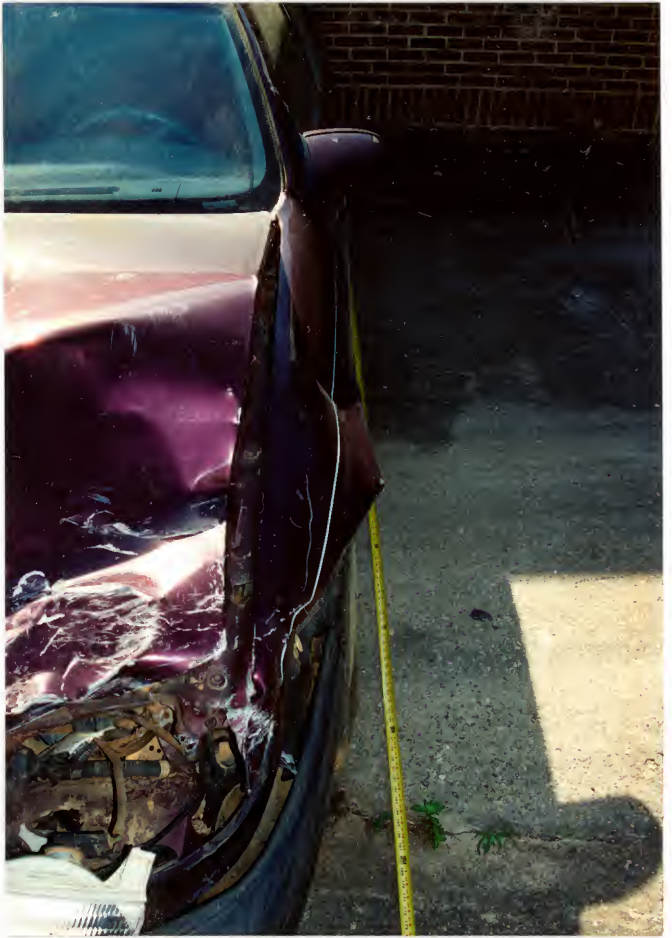


21. Close-up view of the interior contact evidence on the windshield near the windshield header.



22. Lateral view showing the longitudinal displacement of the bumper and hood.

23. Longitudinal view along the left side plane.



24. Longitudinal view along the right side plane.

25. Lateral view from the right side of the vehicle showing the minimal longitudinal displacement of the bumper and hood.



26. Overall view of the upper radiator support locating the crash sensor.



27., 28. Views of the upper radiator support bracket showing the location of the crash sensor.

29. View of the left bumper energy absorption device (EAD).



30. View of the right front bumper energy absorption device (EAD).



31., 32. Lateral views of the left side plane.



33., 34. Left and right rear corner views.



35. Angular view of the right front corner.



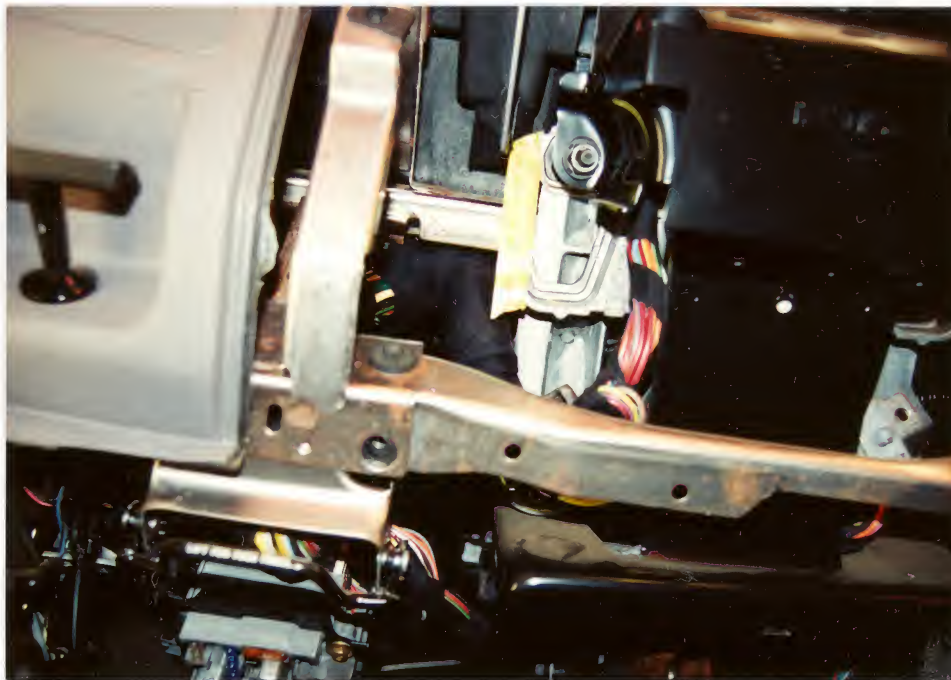
36. Angular view of the driver's side air bag module and left instrument panel.



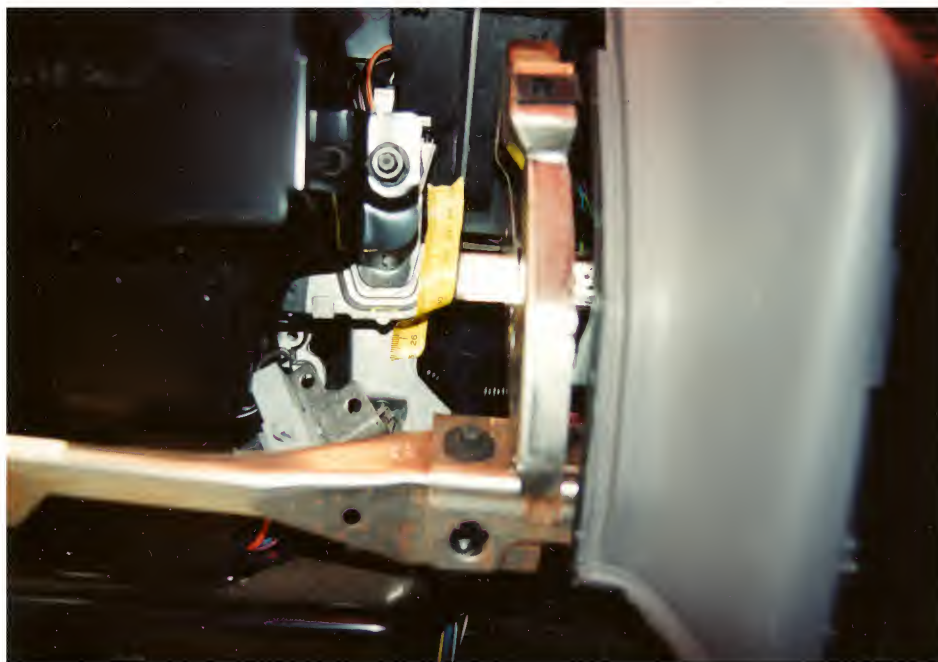
37. View of contact evidence on the instrument panel and knee bolster.



38. Close-up view of contact evidence on the knee bolster.



39. View of the left shear capsule showing the movement of the shear plate.



40. View of the right shear capsule showing the movement of the shear plate.

41. Lateral view of the steering wheel highlighting the longitudinal displacement of the steering column.

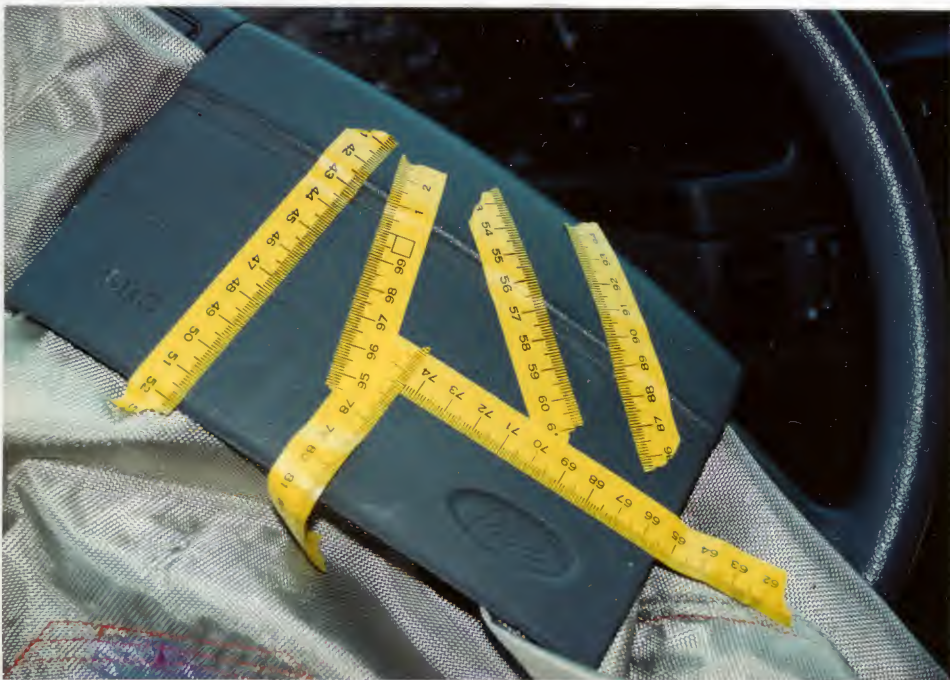


42. Vertical view of the driver's area.

43. View of contact evidence on the windshield glazing just below the windshield header.



44. View of the driver side air bag module cover and the air bag vent ports located on the reverse side of the air bag.



45., 46. Views of the driver side air bag module cover before and after the application of the calibrated tape.



47., 48. Views showing the position of the lower air bag module flap and the contact evidence along the horizontal tear seam line of the flap.



49. View showing a small linear blue transfer mark on the front surface of the air bag.



50. View of the large blue/black color transfer mark on the reverse side of the air bag.



51. Lateral view of the front seat showing the relative distance between the seat back support and the steering wheel.



52. Lateral view of the front seat with the driver seated in her simulated driving position.



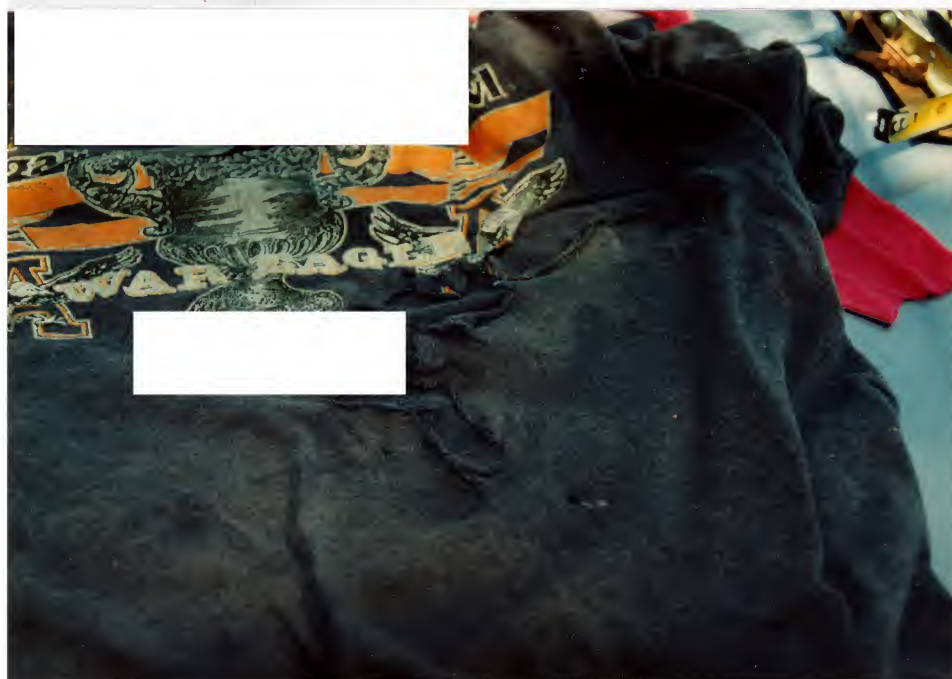
53., 54. Views showing the location of the driver's torso and lower extremities with respect to the air bag, steering wheel rim, and lower instrument panel.



55. View of the driver's seated position from the right side of the vehicle.



56. View of the shirt worn by the driver at the time of the crash.



57., 58. Close-up views showing the tear pattern located along the lower left side adjacent to the word "Orleans" and the surrounding discoloration resulting from contact with the air bag during deployment.



59. View of the garment worn under the shirt at the time of the crash.



60. View of the maternity shorts worn by the driver at the time of the crash.

61. View of the center instrument panel.



62. View of the right instrument panel.



63. Angular view of the instrument panel.



64. Perpendicular view of the left front door surface.



65. Close-up view of contact evidence along the left side roof rail.



66. View of the rear seat area from the right side of the vehicle.



67. View of the rear seat taken from the left side of the vehicle.



68. View of the left rear seat cushion showing abrasion of the seat fabric consistent with the installation and use of a child safety seat.



69. Frontal view of the 1989 Chevrolet S10 pickup truck (Vehicle #2) showing the overall plane of contact .



70. View of the damage noted on the windshield.



71. Close-up view of contact damage to the windshield.



72. View of the left frontal area showing crash damage.



73., 74. Left front corner views.

75. Lateral view of the front plane from the left side of the vehicle showing the extent of rearward crush.



76. View of the left front fender.

77. Overhead longitudinal view of the vehicle's left side plane.



78. Left rear corner view.



79. Right rear corner view.



80. Right front corner view.



81. Angular view of the instrument panel (seats, steering column, and instrument panel accessories were removed by the salvage company).



82. View of the left side instrument panel and windshield.

83. Contact evidence on the windshield.



84. Close-up view of the hole in the windshield glazing.

Appendix B

SMASH Algorithm

Summary of Results Using Damage

SCI Case No. 95-09

	Speed Change (Damage)	Impact Speed (Damage and Spinout)
Vehicle #1		
Total	13 km/h (8 mph)	18 km/h (11 mph)
Longitudinal	-13 km/h (-8 mph)	18 km/h (11 mph)
Latitudinal	0 km/h (0 mph)	0 km/h (0 mph)
PDOF Angle	0 ½	
Energy Dissipated	= 9648 Joules (7115 Ft-Lb)	
Barrier Equivalent Speed	= 10.9 km/h (6.8 mph)	
Calculated using crush coefficients entered by the user.		

Vehicle #2		
Total	16 km/h (10 mph)	24 km/h (15 mph)
Longitudinal	-16 km/h (-10 mph)	24 km/h (15 mph)
Latitudinal	0 km/h (0 mph)	0 km/h (0 mph)
PDOF Angle	0 ½	
Energy Dissipated	= 23247 Joules (17144 Ft-Lb)	
Barrier Equivalent Speed	= 16.9 km/h (10.5 mph)	
Calculated using crush coefficients entered by the user.		

Separation Results

	Vehicle #1 áááááááááááá	Vehicle #2 áááááááááááá
Separation (Using Spinout)		
us	5 km/h (3 mph)	8 km/h (5 mph)
vs	3 km/h (2 mph)	10 km/h (6 mph)
psisd	-41 deg/sec	-73 deg/sec

General Information

	Vehicle #1 áááááááááááá	Vehicle #2 áááááááááááá
Year	1992	1989
Make	Ford	Chevrolet
Model	Taurus GL	S10
CDC	12FLEE1	12FLEE2
Side Damaged	F	F
PDOF Angle	0 ½	0 ½
Heading Angle	360 ½	180 ½
Calculation method: Vehicle's Crush Coeff. Vehicle's Crush Coeff.		
d0 crush coeff.	102.20 sqrt(N)	105.71 sqrt(N)
d1 crush coeff.	7.25 sqrt(N)/cm	7.98 sqrt(N)/cm

Damage Information

	Vehicle #1 áááááááááááá Yes	Vehicle #2 áááááááááááá Yes
Vehicle Damage Known		
Crush Length	147.0 cm (58 in)	148.0 cm (58 in)
C1	4.0 cm (2 in)	32.0 cm (13 in)
C2	2.0 cm (1 in)	4.0 cm (2 in)
C3	1.0 cm (0 in)	1.0 cm (0 in)
C4	0.0 cm (0 in)	0.0 cm (0 in)
C5	0.0 cm (0 in)	0.0 cm (0 in)
C6	0.0 cm (0 in)	0.0 cm (0 in)
D	-56.8 cm (-22 in)	-61.9 cm (-24 in)
D'	-84.6 cm (-33 in)	-109.3 cm (-43 in)

Scene Information

Vehicle #1
 áááááááááá

Vehicle #2
 áááááááááá

Impact

x position 5.2 m (17.1 ft)
 y position 3.8 m (12.5 ft)
 heading angle 360 ½

9.7 m (31.8 ft)
 2.2 m (7.2 ft)
 180 ½

Rest

x position 5.6 m (18.4 ft)
 y position 4.0 m (13.1 ft)
 heading angle 349 ½

8.5 m (27.9 ft)
 0.8 m (2.5 ft)
 140 ½

Side-Slip Angle

0 ½

0 ½

Motion Information

Vehicle #1
 áááááááááá

Vehicle #2
 áááááááááá

Did Vehicle Rotate?

Yes

Yes

Did Rotation Stop?

No

No

End of Rotation x position

5.6 m (18.4 ft)

8.5 m (27.9 ft)

End of Rotation y position

4.0 m (13.1 ft)

0.8 m (2.5 ft)

End of Rotation angle

349.0 ½

140.0 ½

Curved Path?

No

No

Curved Path x position

0.0 m (0.0 ft)

0.0 m (0.0 ft)

Curved Path y position

0.0 m (0.0 ft)

0.0 m (0.0 ft)

Direction of Rotation

CCW

CCW

Amount of Rotation

< 360½

< 360½

Was There Sustained Contact Between the Vehicles? No

B4

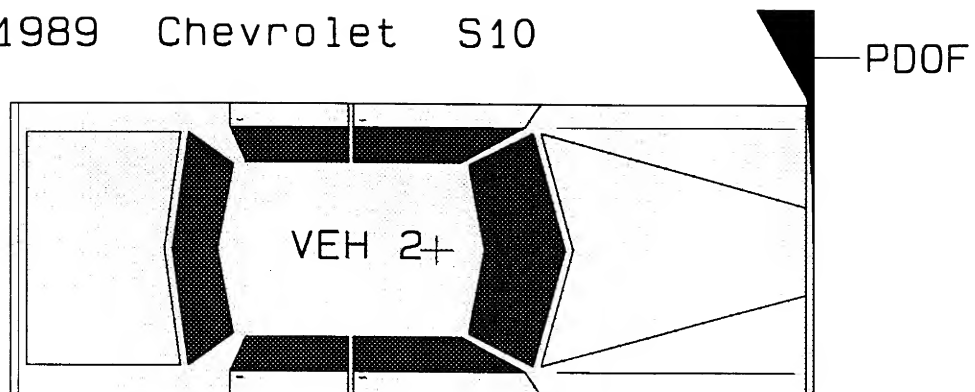
Friction Information

	Vehicle #1 áááááááááá	Vehicle #2 áááááááááá
Rolling Resistance		
Left Front Wheel	0.30	0.01
Right Front Wheel	0.30	0.01
Left Rear Wheel	0.01	0.30
Right Rear Wheel	0.01	0.30
Coefficient of Friction = 0.65		

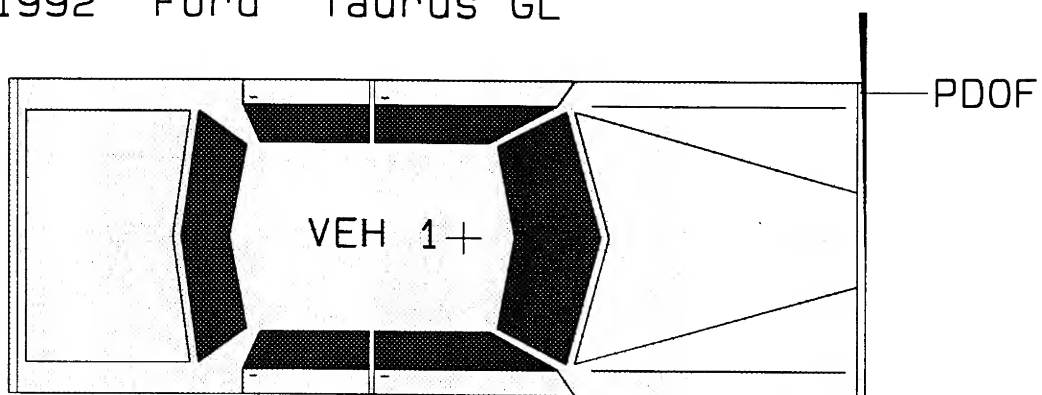
Vehicle Dimensions

	Vehicle #1 áááááááááááá	Vehicle #2 áááááááááááá
Length	490.5 cm (193 in)	452.6 cm (178 in)
Width	180.7 cm (71 in)	164.3 cm (65 in)
Wheelbase	269.3 cm (106 in)	275.1 cm (108 in)
Weight	1569 kgs	

1989 Chevrolet S10



1992 Ford Taurus GL



SCI Case No. 95-09

